Electromagnetics and Simultaneous Switching Noise

Dale Becker, UIUC, Jan. 1993

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Presented at: The EM Symposium in Honor of Raj Mittra
Sept. 27, 2014

Outline

- History: ΔI Noise or SSN – Electromagnetic Extraction or Circuit Simulation
- The "Myths" – Commonly abused concepts
  - Ground
  - Self-Inductance
  - Shielding and Referencing
- Future: Power Integrity – Circuit Simulation or Electromagnetic Extraction

ΔI Noise / SSN

February 6, 1978

MEMORANDUM TO FILE

SUBJECT: Why the TCM Works

REFERENCES:
(1) F. W. Grover - Inductance Calculations Working Formulas and Tables
(2) B. J. Rubin to File - "Third Pass 'A' Machine Logic Module, Connector and Board Electrical Packaging Parameters" - dated 3/14/77.
(3) B. J. Rubin to File - "Signal Propagation Characteristics on Parallel and Diagonal Mesh TCM's" - dated 5/11/77.

from: Rubin

In this memo, we will develop and use a ΔI model to obtain general information on current flows and effective power supply inductances within the logic TCM.

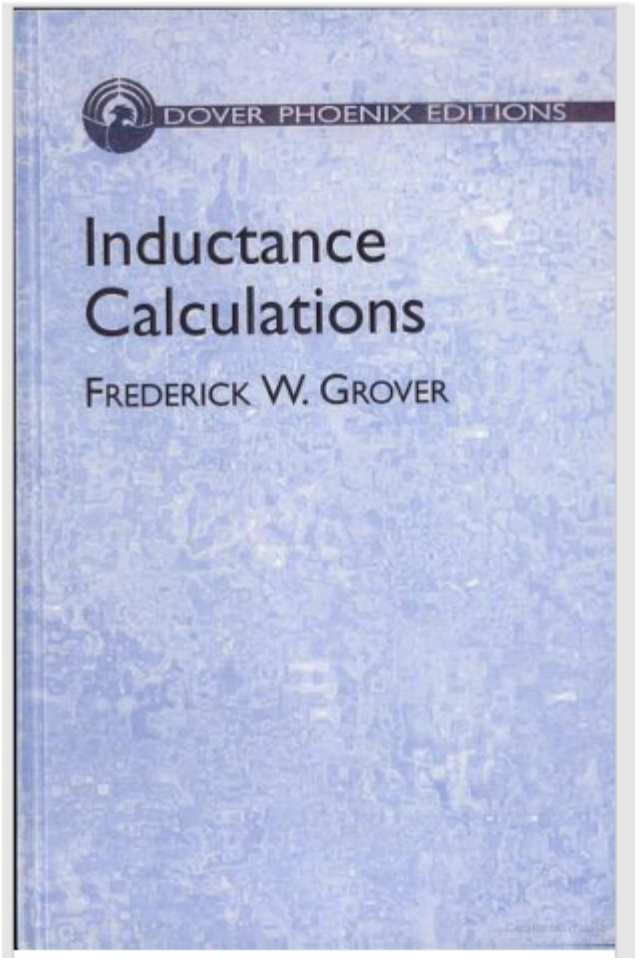
The model, which consists of capacitive-inductive

May 8, 1979

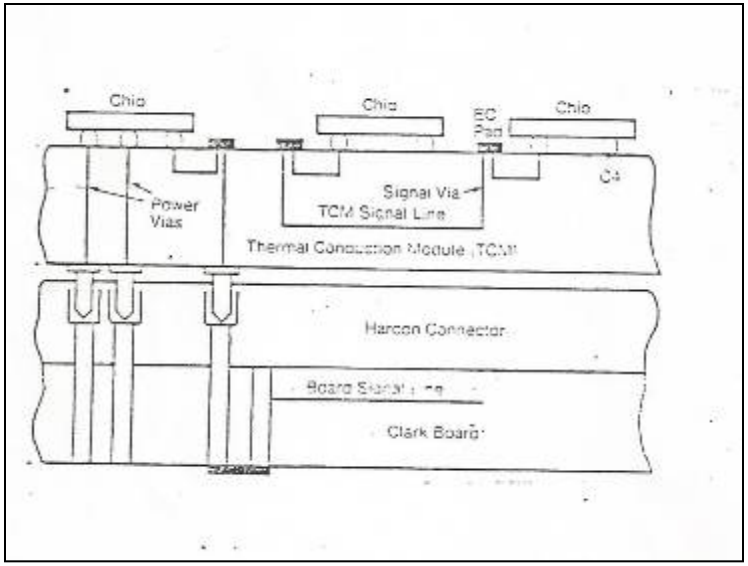
MEMORANDUM TO FILE

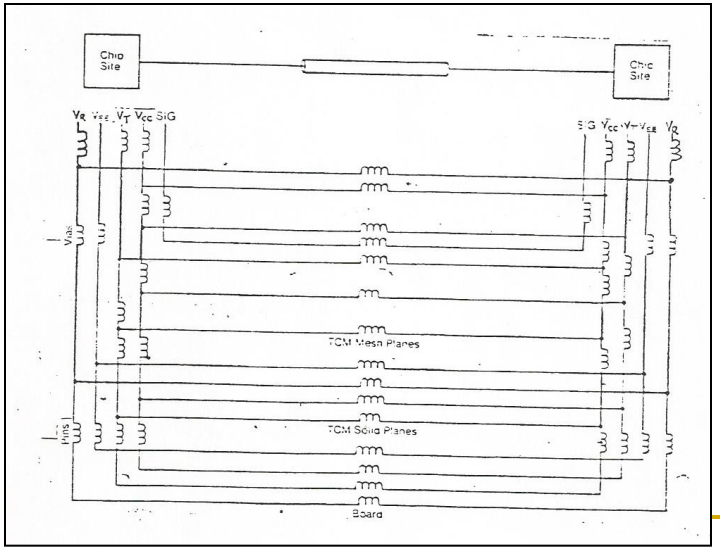
SUBJECT: A Study on the Simultaneous Switching of Driver Circuits in the TCM Environment

REFERENCES:
(1) Private Communication with S. R. Musterman
(2) "Statistical Worst Case" Private Communication with T. R. Scott and T. P. Walker, Jr.
(3) "Methodology and Computer Aids for the Noise Tolerance of ECL Logic Gates" - G. A. Katopis - 12th Asilomar Conference, November, 1978
(4) "Statistics of the DC Noise Margins for the Internal Circuits of MS-416" - G. A. Katopis - Memo to File - dated November 1, 1978
(5) "DCLV - A Function for DC Noise Margins Calculations in ASTAP" - A. J. Jimenez, et al - Memo to ASTAP Users - dated October 15, 1978
(6) "Sensitivity of the AC Noise Tolerance Curves for 2 mA Internal Circuits of MS-416" - G. A.



Inductance


Chip
Chip
EC Pad
Chip
C4
Power Vias
Signal Via
TCM Signal Line
Thermal Conduction Module (TCM)
Harcon Connector
Clark Board


Chip Site
Chip Site
TCM Mesh Planes
TCM Solid Planes
Board

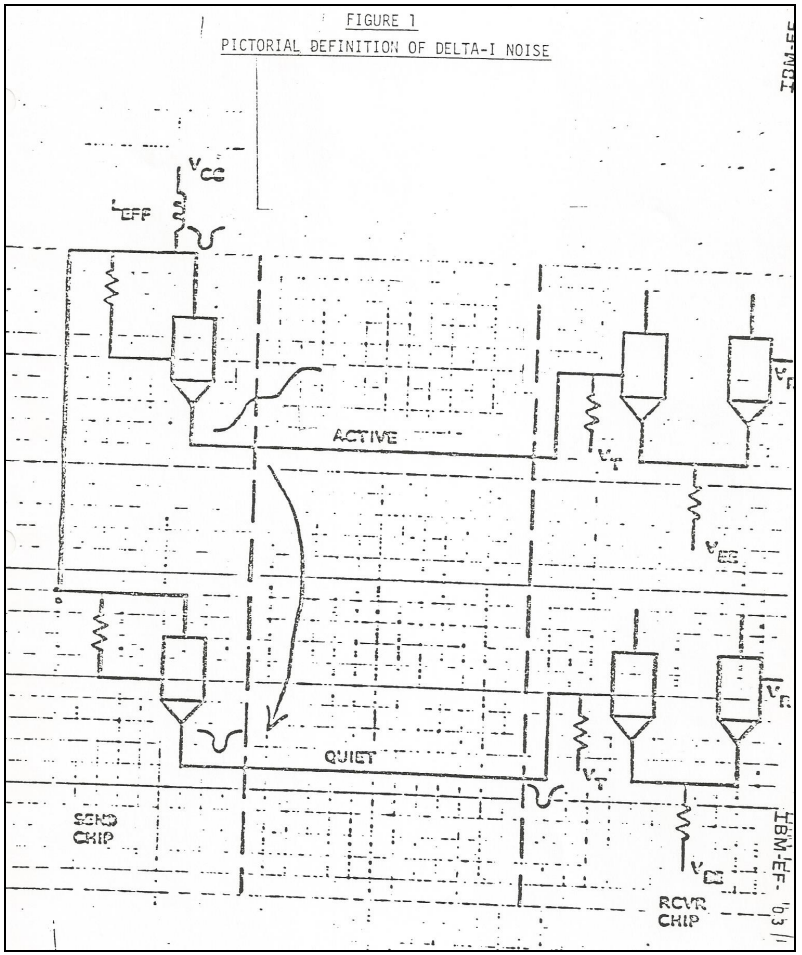
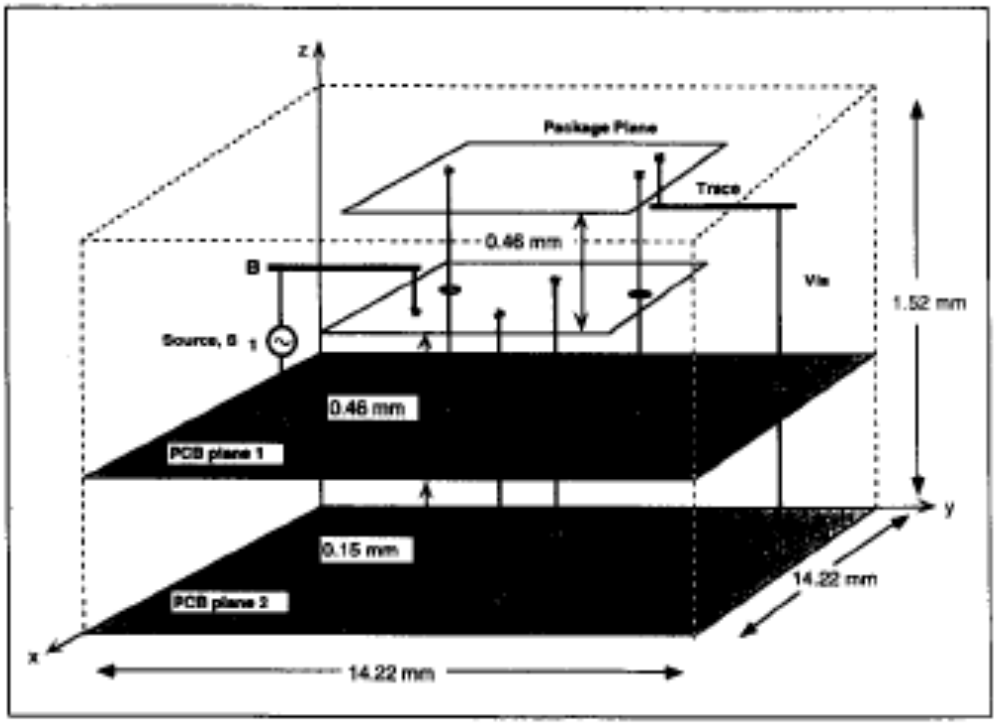


FIGURE 1
PICTORIAL DEFINITION OF DELTA-I NOISE
ACTIVE
QUIET
SEND CHIP
RCVR CHIP

Electromagnetic Fields

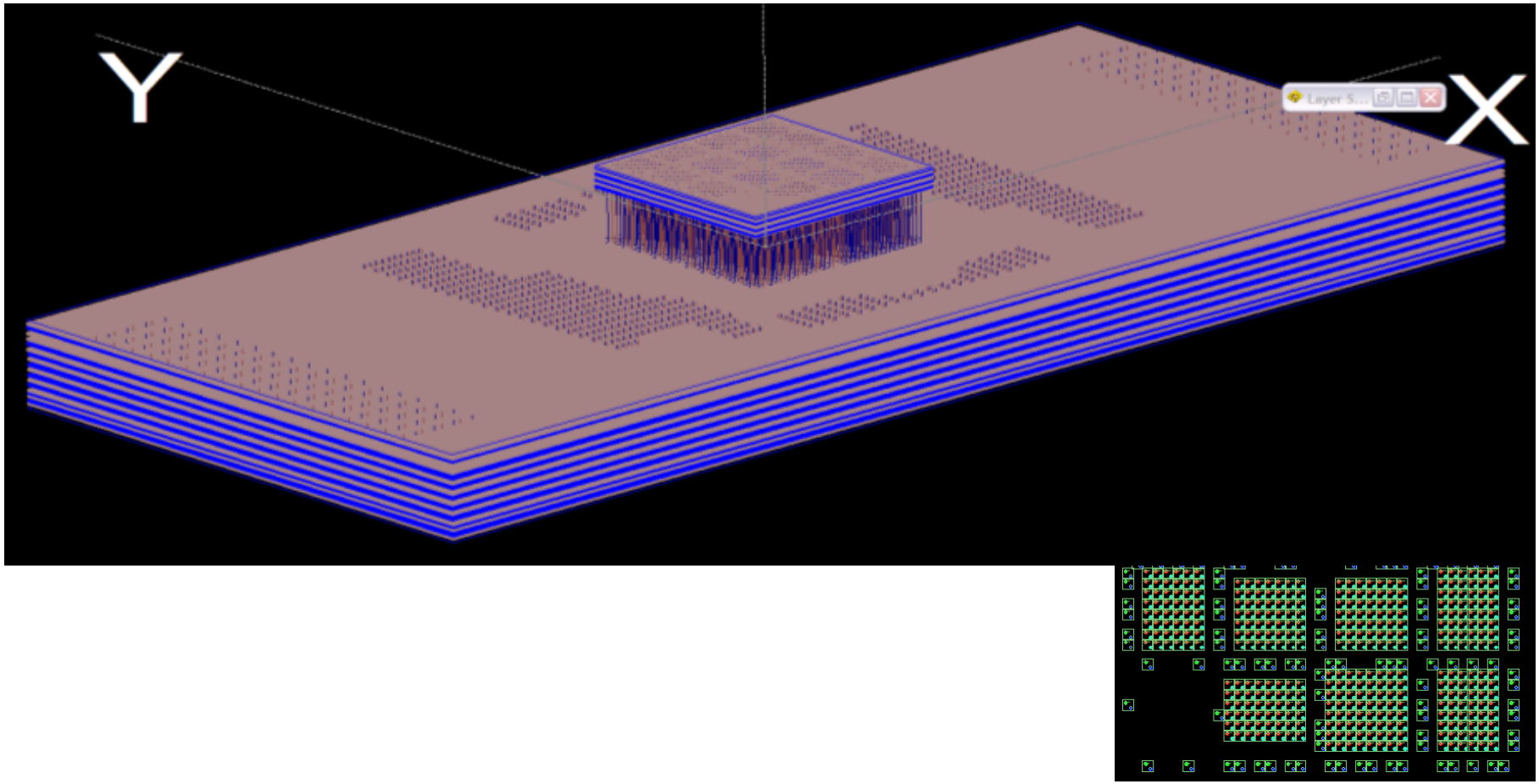


IEEE TRANSACTIONS ON MICROWAVE THEORY AND TECHNIQUES, VOL. 42, NO. 9, SEPTEMBER 1994 1791

Efficient Modeling of Power Planes in Computer Packages Using the Finite Difference Time Domain Method

Raj Mittra, *Fellow, IEEE*, Siva Chebolu and Wiren Dale Becker, *Member, IEEE*

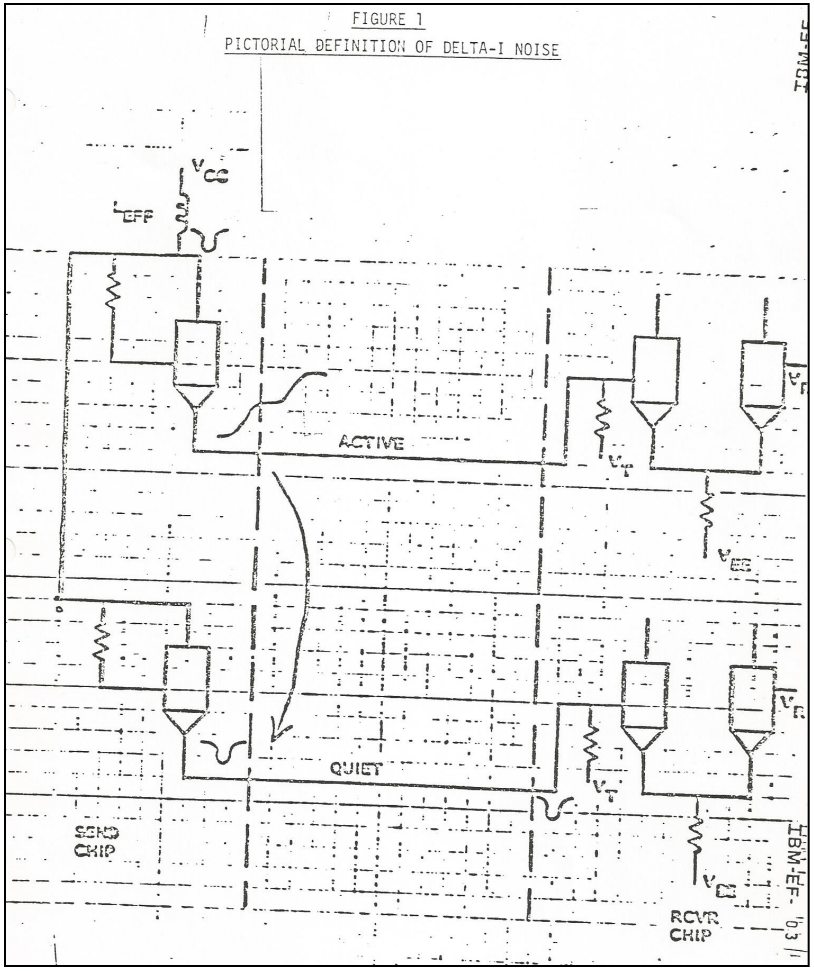
Scaling up



Garben, et. al., “Mid-Frequency Delta-I Analysis of Complex Computer System Boards With Multiprocessor Modules and Verification by Measurements,” IEEE Trans. Adv. Pkg, Aug. 2001

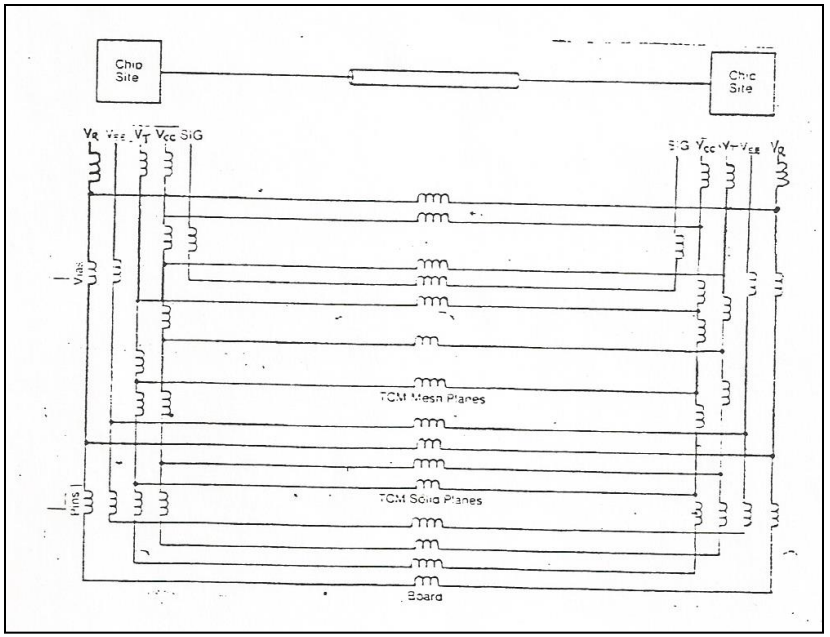
Ground

- Circuit simulation needs a “Ground Node”
- Digital designs have a “Ground Plane”
- EM fields are local
- Circuit simulation of SSN noise depends on a correct reference



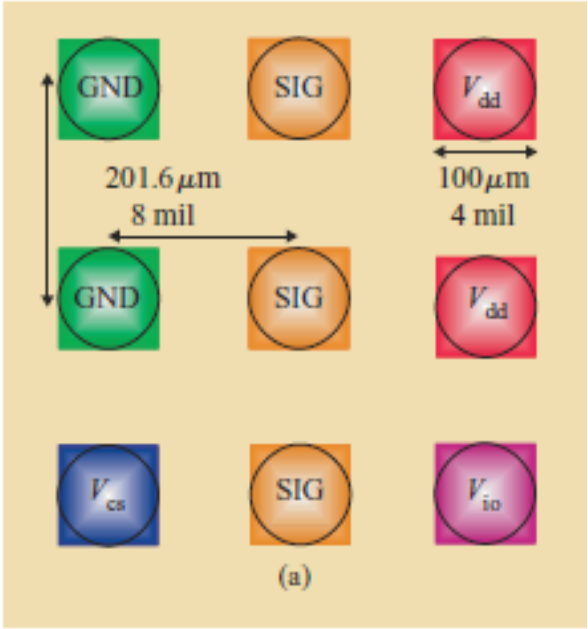
Self-Inductance

- Leff is still a powerful concept
- Leff depends on a current – a loop
- Circuit simulation depends on proper loop definition



Shielding and Referencing

- *Return path* is what a shield or reference usually means in an SSN context
- Return path is a complex topology of voltages and signals



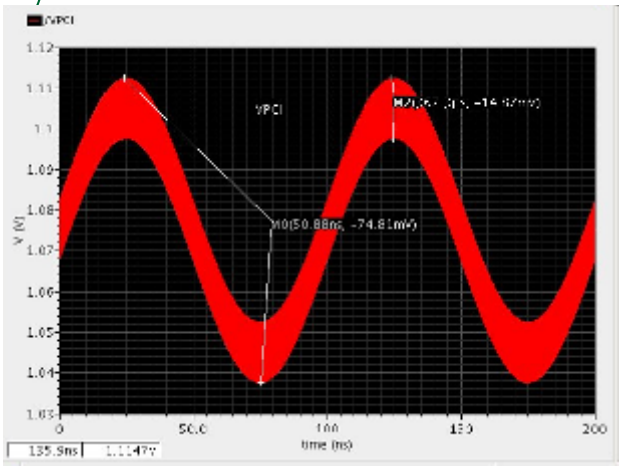
Packaging design challenges of the IBM System z10 Enterprise Class server

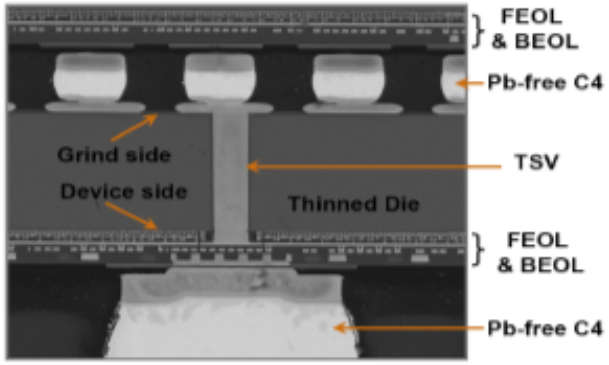
T.-M. Winkel
H. Harrer
D. Kaller
J. Supper
D. M. Dreps
K. L. Christian
D. Cosmadelis

IBM J. RES. & DEV. VOL. 53 NO. 1 PAPER 10 2009

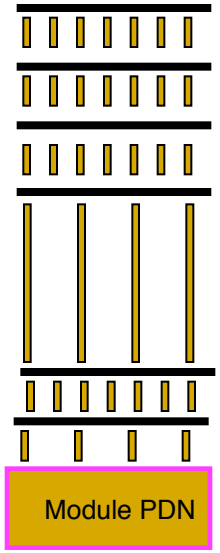
Future: Power Integrity

- SSN: Jitter is key quantity – Circuit simulation
- 3D Stacks: Rediscovery with modern technology





Knickerbocker, et. al. ECTC 2012
2.5D and 3D Technology Challenges and Test Vehicle Demonstrations



Summary

- Switching noise analysis depends on electromagnetic fundamentals represented in a circuit simulation